DOE Subsurface Technology and Engineering RD&D (SubTER) Overview

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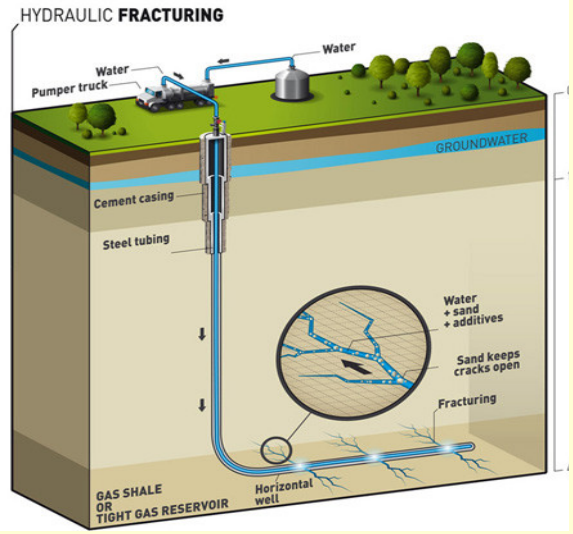
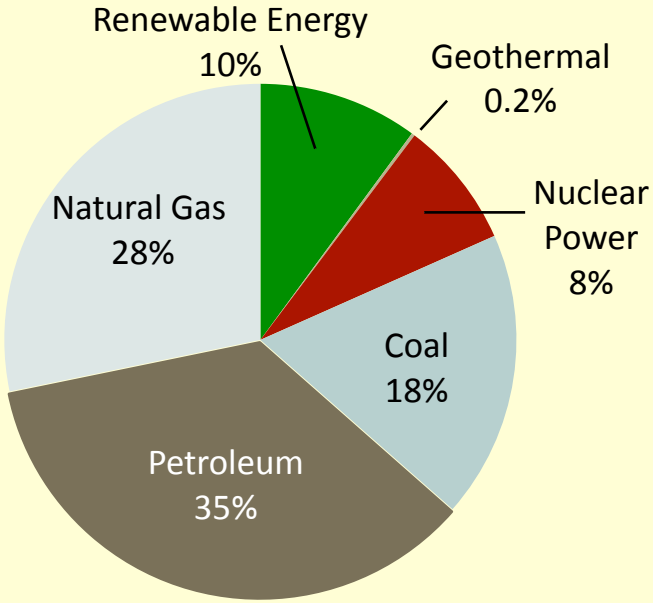
Mastery of the Subsurface needed for a Safe and Secure U.S. Energy Future: The Technical Challenge

Shale hydrocarbon production

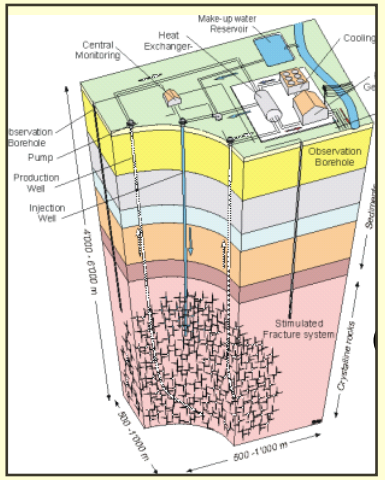


Primary Energy Use by Source, 2014

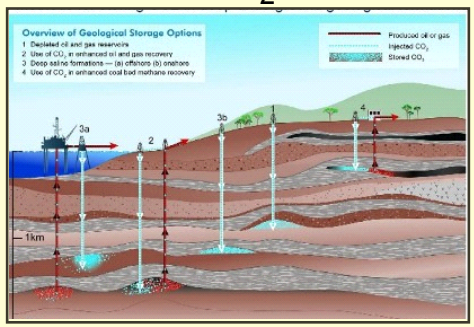
Quadrillion Btu [Total U.S. = 98.3 Quadrillion Btu]



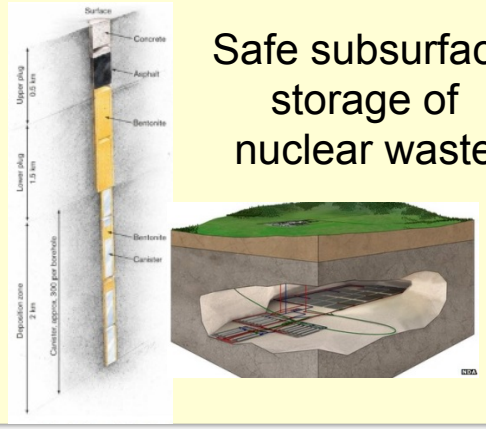
Enhanced geothermal energy



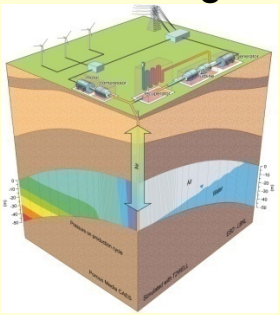
Safe subsurface storage of CO_2



Safe subsurface storage of nuclear waste



Compressed Air Energy Storage



A path-bending Crosscutting Challenge:

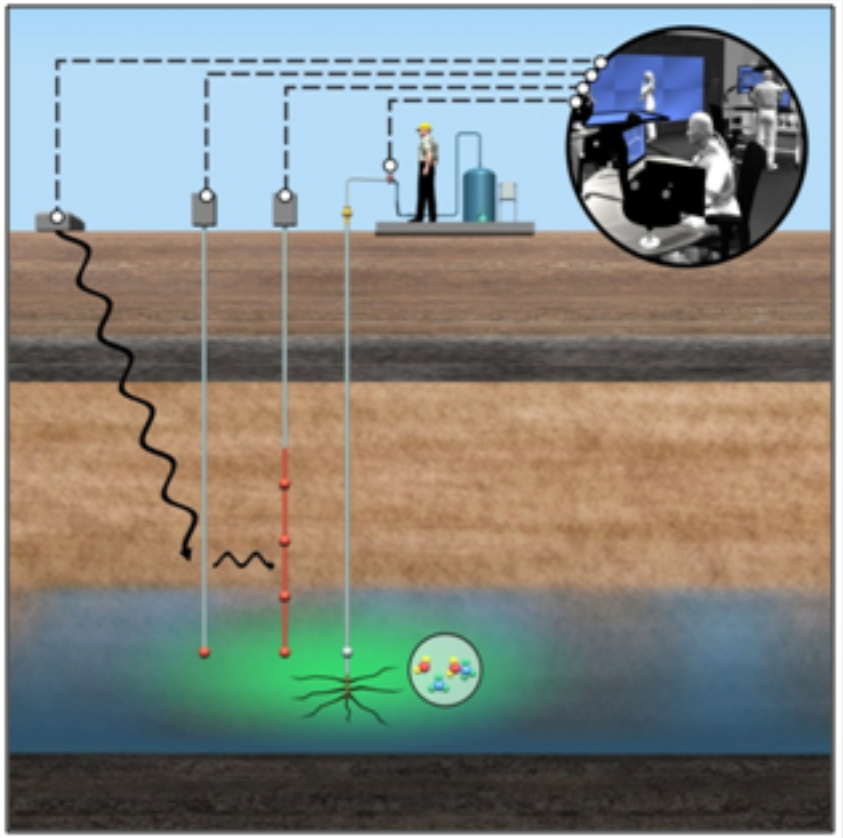
"Adaptive Control of subsurface fractures, reactions and flow"

SubTER: Subsurface Technology Research, Development & Demonstration

Within 10 Years:

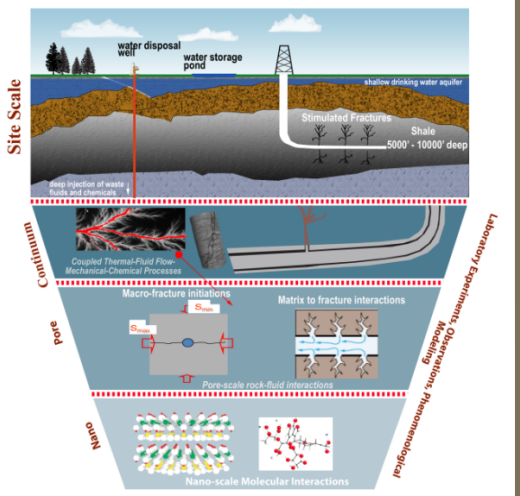
- A ten-fold increase of U. S. electricity production from **geothermal** reservoirs
- Double **hydrocarbon** production from tight reservoirs
- Establish practical feasibility of deep borehole **disposal**
- Large-scale safe **CO_2 sequestration** to meet targets described in the President's Climate Action Plan;

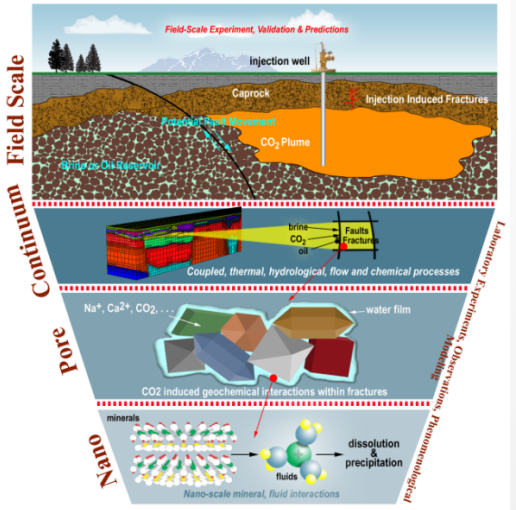
Concurrent protection of the environment (water and air resources, induced seismicity, etc)



General Technical Baseline: State of Knowledge & Practice

- Reservoir stress distribution and material properties are highly heterogeneous and largely unknown
- Mechanistic understanding of multi-scale processes that influence stress distribution and thus fracture formation and flow is lacking - limits both production and subsurface storage
- Industry is developing approaches to improve fracture creation, commonly guided by empirical field evidence. Industry not attempting 'real time' control
- Significant public concern and uncertainty associated with environmental risks





Today we cannot accurately image, predict, or control fractures with confidence or in real-time.

Subsurface Engineering: Common Subsurface Challenges

Discovering, Characterizing, and Predicting
Efficiently and accurately locate target geophysical and geochemical responses, finding more viable and low-risk resource, and quantitatively infer their evolution under future engineered conditions

Accessing
Safe and cost-effective drilling, with reservoir integrity

Engineering
Create/construct desired subsurface conditions in challenging high-pressure/high-temperature environments

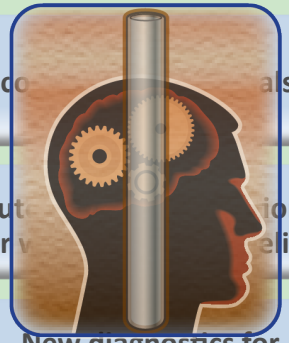
Sustaining
Maintain optimal subsurface conditions over multi-decadal or longer time frames through complex system evolution

Monitoring
Improve observational methods and advance understanding of multi-scale complexities through system lifetimes

Subsurface Crosscut Framework

Adaptive Control of Subsurface Fractures and Fluid Flow

Intelligent Wellbore Systems



New diagnostics for wellbore integrity

Remediation tools and technologies

Fit-for-purpose drilling and completion tools (e.g. anticipative drilling, centralizers, monitoring)

HT/HP well construction / completion technologies

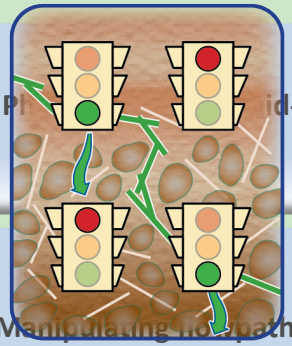
Subsurface Stress & Induced Seismicity

and induced seismicity

Relating stress manipulation and induced seismicity to permeability

Applied risk analysis of subsurface manipulation

Permeability Manipulation



Characterizing fractures, dynamics, and flows

Novel stimulation methods

New Subsurface Signals

data

Adaptive control processes

Diagnostic signatures and critical thresholds

Energy Field Observatories

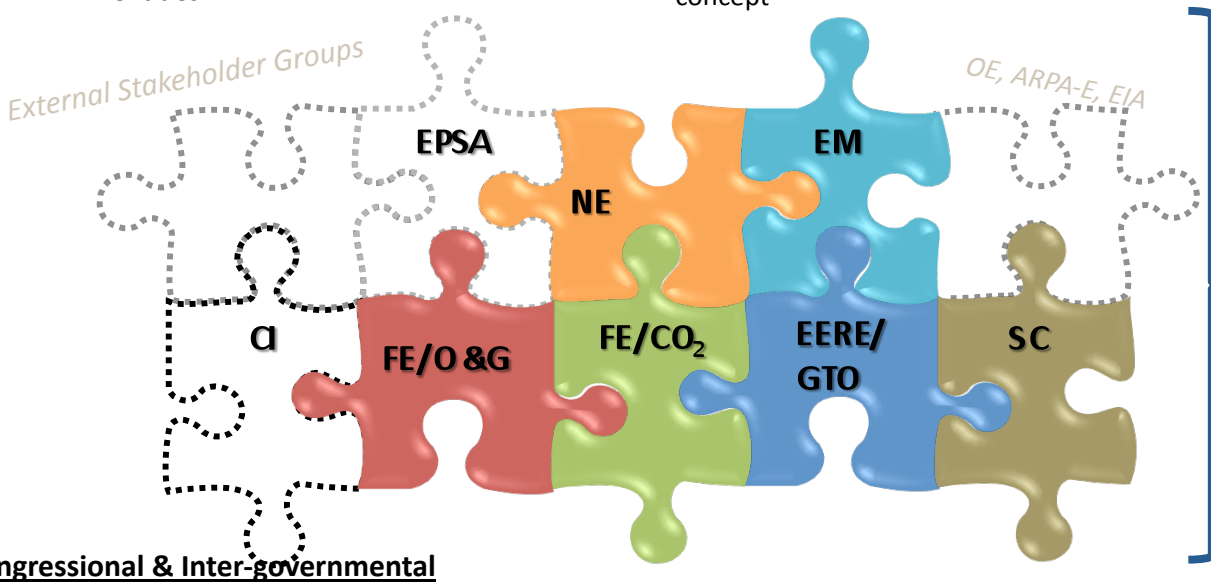
Fit For Purpose Simulation Capabilities

SubTER: DOE Office Involvement

Energy Policy & Systems Analysis
- Advisement: Secretary of Energy
- Policy: low-carbon and secure energy economy
- Technical assistance: States and local entities

Nuclear Energy
- Policy and technology: disposition of used nuclear fuel and waste
- R&D: deep borehole disposal concept

Environmental Management
- Modeling and tools: subsurface evaluation and characterization
- Cleanup: nuclear weapons legacy



SubTER Tech Team
- Encompasses relevant offices
- Reports to Under Secretary for Energy and Science
- Identifies and facilitates crosscutting subsurface R&D and policy priorities for DOE
- Develops collaborative spend plan and funding scenarios

Congressional & Inter-governmental Affairs
- Interactions: elected officials, regulators, and stakeholders
- Information access for change agents

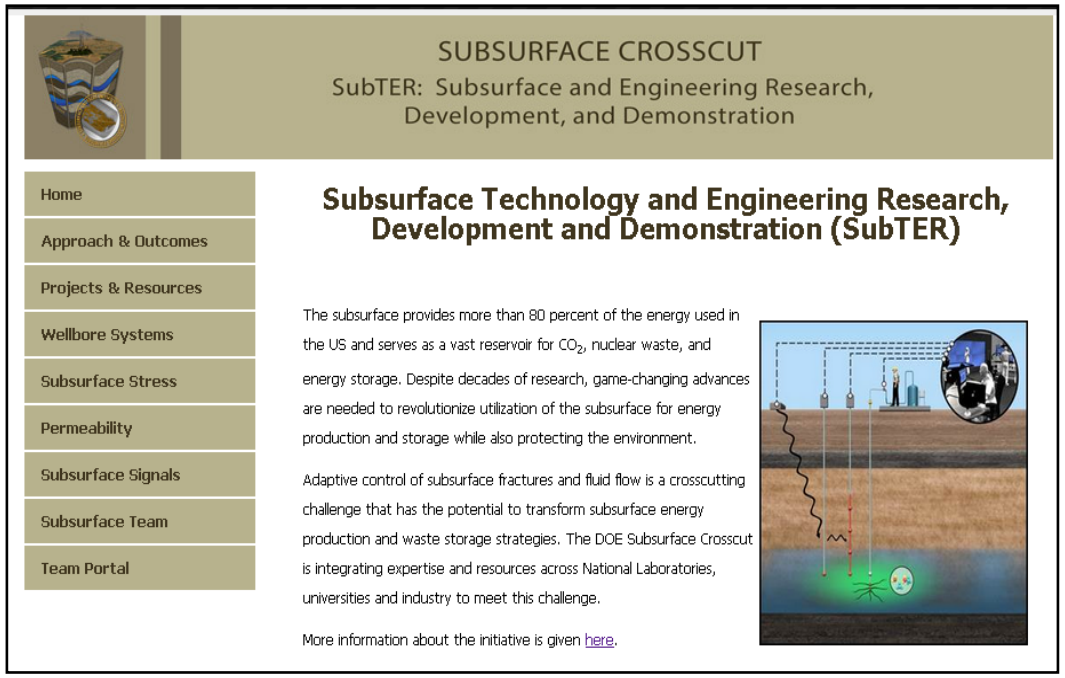
Fossil Energy/Oil & Gas
- R&D and access: clean, affordable traditional fuel sources
- R&D: drilling, well construction and integrity, and hydraulic fracturing technologies

Fossil Energy/Carbon Storage
- Policy and technology: challenges of CO_2 storage to inform regulators, industry, and the public
- R&D: CO_2 offshore and onshore storage

Energy Efficiency & Renewable Energy/ Geothermal Technologies Office
- R&D: locate, access, and develop geothermal resources
- R&D: access, create, and sustain enhanced geothermal systems (EGS)

Science
- Basic research: geology, geophysics, and biogeochemistry
- Expertise: subsurface chemistry, complex fluid flow

For More Information: SubTER
Adaptive Control of Subsurface Fractures & Fluid Flow



SUBSURFACE CROSSCUT

SubTER: Subsurface and Engineering Research, Development, and Demonstration

Home
Approach & Outcomes
Projects & Resources
Wellbore Systems
Subsurface Stress
Permeability
Subsurface Signals
Subsurface Team
Team Portal

Subsurface Technology and Engineering Research, Development and Demonstration (SubTER)

The subsurface provides more than 80 percent of the energy used in the US and serves as a vast reservoir for CO_2, nuclear waste, and energy storage. Despite decades of research, game-changing advances are needed to revolutionize utilization of the subsurface for energy production and storage while also protecting the environment.

Adaptive control of subsurface fractures and fluid flow is a crosscutting challenge that has the potential to transform subsurface energy production and waste storage strategies. The DOE Subsurface Crosscut is integrating expertise and resources across National Laboratories, universities and industry to meet this challenge.

More information about the initiative is given here.

http://SubTER.lbl.gov

ENERGY | Office of the Under Secretary for Science and Energy

Energy Department Subsurface Crosscut

Addressing Common Subsurface Challenges

The ability to master the subsurface continues to elude researchers and practitioners working on a variety of energy production and storage applications. The DOE is implementing a new collaborative model to tackle this "energy grand challenge" through a coordinated RD&D strategy. Common challenges faced by the participating offices include:

1. **Discover, Characterize, and Predict**
   - accurately characterizing the subsurface using integrated geophysical and geochemical technologies
   - Quantitatively inferring subsurface evolution under current and future engineered conditions
   - Finding viable, low-risk resources
2. **Access**
   - safe, cost-effective reservoir integrity
3. **Engineer**
   - Creating/constructing desired subsurface conditions in challenging high-pressure/high-temperature environments
4. **Sustain**
   - maintaining optimal subsurface conditions over multi-decadal or longer time frames through complex system evolution
5. **Monitor**
   - improving observational methods to advance understanding of multi-scale complexities through system lifetimes

The SubTER technical team identifies and facilitates crosscutting RD&D and policy activities for DOE, to enable programs with common technical challenges to work together toward solutions. The SubTER crosscut reports to the Under Secretary for Science and Energy and leverages program budget priorities to better plan for investment and assistance. While each of the offices brings new activities to the table, the sector benefits as a whole from crosscutting solutions. Partnerships include Departmental programs and offices, labs, academia, and industry, as well as synergies across federal agencies.

Subsurface Technology and Engineering Research, Development, and Demonstration (SubTER) Crosscut

Subsurface energy sources satisfy over 80% of total U.S. energy needs. Finding and effectively exploiting these resources while mitigating impacts of their use constitute major technical and socio-political challenges. Still, the opportunities are vast. Next generation advances in subsurface technologies will enable increases in domestic natural gas supplies, as well as 100+ GWe of clean, renewable geothermal energy. The subsurface provides hundreds of years of safe storage capacity for carbon dioxide (CO_2), and opportunities for environmentally responsible management and disposal of hazardous materials and other energy waste streams. The subsurface can also serve as a reservoir for energy storage for power produced from intermittent generation sources. These opportunities have immediate connection to societal needs and administration priorities. Clean energy deployment and CO_2 storage are critical components of the President's Climate Action Plan, necessary to meet the 2050 greenhouse gas (GHG) emissions reduction target. Increasing domestic energy supply from greater hydrocarbon resource recovery, in a sustainable and environmentally sound manner, are also Administration goals that enhance national security and fuel economic growth.

Who's Involved?

Representing the geosciences, research, modeling, technology development, policy, and stakeholders, the participating program offices include:

- Fossil Energy-Oil and Gas
- Fossil Energy-CO_2 Storage
- EERE-Geothermal Technologies Office
- Nuclear Energy
- Environmental Management
- Office of Science
- ARPA-E
- Office of Electricity
- Energy Policy & Systems Analysis
- Congressional & Intergovernmental Affairs
- Energy Information Administration

energy.gov/subsurface-tech-team